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Perspectives and challenges in distance learning of mathematics: A survey among mathematics students in public tertiary education

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Abstract

This study aims to examine the contribution of challenge factors to the perspective of distance mathematics learning and the level of challenges faced by students within public higher education institutions in Malaysia. A quantitative approach was employed, involving 51 mathematics students selected through purposive sampling. Principal component factor analysis revealed six key factors: students' perspective, social issues, lecturer issues, accessibility, academic issues, and generic skills. The findings indicated that lecturer-related issues emerged as the primary challenge in distance mathematics learning. Multiple regression analysis showed that social issues were significant positive predictors of students' perspectives. Students strongly favored semester postponement, reflecting concerns about the effectiveness of distance mathematics learning. The study recommends strategies to improve social presence such as encouraging peer collaboration, enhancing instructor interaction and creating structured opportunities for social interaction. The findings also emphasize the need for improved lecturer competencies in remote teaching and higher quality digital mathematics teaching materials. These findings provide valuable insights for developing more effective distance learning approaches in mathematics education at the tertiary level.

Keywords: distance learning, mathematics education, higher education, online learning challenges, student perspectives

INTRODUCTION

In this era of globalization with the advancing of information technology where the use of electronic items is undeniably becoming a necessity, there is also a major shift happening in the education field, especially in tertiary education. The term distance learning has now become increasingly prominent in the education world. According to Culduz (2024), the primary components of distance learning are the physical separation of instructors and students during instruction and the use of a variety of technologies to promote communication between students and between teachers. Non-traditional students, including full-time workers, members of the armed forces, non-residents, and those unable to travel to distant places for lectures, have historically been the focus of distance learning.

Distance education has been around for at least two centuries in one form or another (Moore et al., 2011). The transition from asynchronous teacher-student interactions to synchronous work, made possible by the development of the Internet and the use of chat and video conferencing software, is noteworthy. Materials could then be digitalized and distributed asynchronously to the digital world. Most recently, the boom in distance education was made possible by the fusion of the fast Internet, the transformation of paper texts and analogue photo and film material into digital formats, and interactive applications used for teaching and learning (Ploj-Virtič et al., 2021). Due to this transformation, learning institutions have opted to transfer some courses to virtual environments and now, there are plenty of programs that are offered fully online.

A lot of past research has highlighted the benefits of distance learning. The major benefit is flexibility scheduling as remote learning allows students to study at their own pace and on their own schedule which can give them balance on other responsibilities such as work

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Contribution to the literature

- This study contributes to the international discourse on distance mathematics education by providing empirical evidence on challenge factors affecting students' perspectives in higher education institutions.
- The research identifies lecturer-related issues as the primary challenge while social factors emerged as significant positive predictors of students' perspectives, offering insights for enhancing mathematics distance learning globally.
- The findings advance the application of the community of inquiry (CoI) framework to mathematics distance education, emphasizing the interconnection between social, cognitive, and teaching presence in creating effective online mathematics learning environments across different educational contexts.

and family (Sozontova et al., 2021). It also enables breaking down geographical barriers and providing access to education for people all over the world, even from hard-to-reach areas as well as the opportunities to work with more learning resources such as online libraries, databases and video lectures (Garlinska et al., 2023). The chance to revisit lectures and review keynotes from the resources also is one of the benefits of distance learning (Culduz, 2024).

According to Cassibba et al. (2021), there are two facets of remote mathematics instruction to consider from the perspective of the mathematics field. The first, without evaluating the appropriateness of this method, has to do with the fact that university-level math lecturers typically employ a lot of symbols and formulas that they are accustomed to writing for their students to see. The second is that the pupils to whom the instruction is directed have an impact on how mathematics is taught. Teaching mathematics to students enrolled in a mathematics degree course requires a different approach to courses (as well as a different selection of topics) than teaching mathematics to students enrolled in another degree course, both online and in-person. Due to these two aspects, integrating mathematics learning and teaching in distance learning may be a challenge for both lecturers and students.

There are various theories or models that suit the distance learning of mathematics and one of them is the CoI framework. Grounded in the work of John Dewey, it was further developed by Garrison et al.(2000) to capture the essential components of a successful learning experience in online environments namely cognitive presence, social presence, and teaching presence. These components will be the guide for us to further explore perspective and challenges in distance learning of mathematics in higher education.

Barriers to Effective Distance Mathematics Learning

Distance learning is slowly becoming part of the global system of education, more so in the current post-COVID-19 period (Benyamin et al., 2022). Distance learning in mathematics refers to an educational experience where teachers and students are separated in time and space (Zin & Mahmud, 2024). This method becomes more complicated as mathematics is an abstract subject that requires the learner to have a deep conceptual understanding (Murtiyasa & Lathifah, 2023). Some students will find it can be challenging to create mental images and develop comprehensive conceptions especially where instructions are offered online, with little or no physical contact with instructors and fellow students. Instructors are required to adapt not only their curriculum and lessons but to the teaching activities and tests that are expected to be implemented when replacing mathematics class by online training (Dzenite et al., 2021). Teaching strategies including the use of mathematical manipulatives tools, group work and direct concept teaching and human contact may not be effective when translated to a digital format as in the case of online learning. According to the studies, mathematic teachers already encounter pedagogical issues in a traditional environment and specifically through the application of efficient feedback in the teaching process (Mahmud & Yunus, 2018). These already existing gaps in instruction such as attention lapses and hearing loss are increased in distance learning where the large degree of face-to-face interactions and immediate methods of feedback are reduced. This can be proven by a study conducted by Hamat et al. (2021) mathematics students in higher education institutions face difficulties in understanding complex concepts without face-to-face interaction with lecturers.

Murtiyasa and Lathifah (2023) found that the distance learning environment affects students' ability to focus. If such an environment is not conducive to the distance learning process, then it becomes difficult for the students to cope up with their learnings and concentrate on their mathematics learning. According to Hassan and Hassan (2021), student personality is also a challenge that students face in online learning such as lack of discipline and unwillingness to adapt to distance learning activities. Teachers also reported that online attendance in online classes was also generally low among students, making it harder for them to monitor discipline and concentration. Some students even admitted having two screens open on their laptops (Hassan & Irdiana Ibrahim, 2021). Another study done by Sri Bathumalai and Mahmud (2022) disagreed with their students' ability to deliver their work on time. This

has outlined some personality issues among students in online mathematics learning pointing to issues of indiscipline, irresponsibility and less commitment as some of the factors that lead to poor performance among the learners.

Distance mathematics learning through online methods has had a significant impact on students' mental health. A lack of inter-student contact experienced in distance learning has demotivated students when learning mathematics. As pointed out by Meehan and Howard (2023), students complained of low learning motivation especially in the course math because of inadequate physical contact with lecturers and peers. This situation is further exacerbated by the phenomenon of digital fatigue in online mathematics learning. According to Romero-Rodríguez et al. (2023), digital fatigue is physical discomfort arising from excessive use of digital devices, such as mobile phones, tablets, or computers. This leads to some of the symptoms common among learners including headaches, eye strain, and blur synthesis. This problem becomes more serious when students need to have different online classes continuously.

Institutions and involved parties are not prepared to implement distance learning for mathematics comprehensively (Aydin & Deniz Tasci, 2005). The majority of educational institutions are struggling with poor technological infrastructure and proper guidelines for distance learning for mathematics. This is supported by the findings of (Mesuwini & Mokoena, 2024), stated that higher education institutions do not have sufficient technical support systems available that can be utilized to address the technical problems encountered by both lecturers and students while participating in online learning. Additionally, there are significant obstacles related to the mathematical nature of the subject itself, such as the limitations of writing mathematical symbols (Irfan et al., 2020). Other common technical challenges experienced across all levels of mathematics distance learning are unstable internet access, especially facing students in rural and remote areas, unavailability of appropriate technological devices, including laptops and tablets, and difficulties accessing different online learning platforms (Dzenite et al., 2021). Moreover, many of those lecturers find it difficult to manage new digital teaching tools and online learning software because they are not trained (Mardiana, 2020). Some mathematics lecturers were not aware of several challenges that students experienced following the switch to distance learning, creating a disconnect between teaching approaches and student needs (Radmehr & Goodchild, 2022). In addition to this, there is no responsive unit for technical support that responds to technical problems quickly, which leads to a disruption of the distance learning process of mathematics.

All these technical, institutional, and pedagogical challenges significantly impact the effectiveness of online mathematics learning in higher education institutions. The transition to online distance learning has revealed critical gaps in mathematics teaching and learning at the university level, particularly in delivering complex mathematical concepts and maintaining student engagement in virtual environments. Although there are many studies on distance learning, there are several significant research gaps in the Malaysian context. First, most existing studies discuss distance learning in general without focusing on the specific challenges in mathematics learning at a higher education level. Studies tend to focus on technical and infrastructure aspects without deeply examining the effects of online learning on understanding complex mathematical concepts (Ningsih et al., 2023). Second, there is a lack of empirical research exploring the situation of distance mathematics learning specifically in Malaysian public higher education institutions. Although there are several studies conducted in Malaysia, most of them focus on primary and secondary education. This creates a gap in understanding the unique challenges faced by students and mathematics lecturers in local public universities. Third, most previous studies have taken the perspective of institutions or lecturers without giving sufficient attention to the experiences and challenges faced by students. Sari and Madio (2021) explain that students' perspectives are important to understand the effectiveness of online mathematics learning. While the CoI framework has been known as a conceptual model for understanding online learning processes through social, cognitive, and teaching presence, little research has been dedicated to the application of this framework in Malaysian public universities for distance mathematics education. The study by Ling and Mahmud (2023) investigated the challenges mathematics instructors face when teaching sentence-based mathematics problem-solving skills create significant barriers that become even more complex when implementing remote learning approaches. These gaps indicate the need for more focused and in-depth research to specifically examine the challenges of distance mathematics learning in Malaysian public universities and to consider student perspectives as key stakeholders in the learning process. By addressing these gaps, a more comprehensive understanding of the challenges and needs in online mathematics learning at a higher education level can be produced, thereby helping in the development of more effective strategies and solutions.

Therefore, this study aims to examine the contribution of challenge factors to the perspective of distance mathematics learning and the level of challenges faced by students in distance learning for mathematics. It is important to better understand this phenomenon as it will give insight into the current and

necessary improvements needed in distance mathematics learning at higher education institutions. To address these objectives, this study seeks to answer the following research questions:

1. What are the significant challenge factors that contribute to students' perspectives on distance mathematics learning?
2. What is the level of challenges experienced by students in mathematics distance learning?

METHODOLOGY

A quantitative approach was chosen for this study by adapting the Aboagye et al. (2020) questionnaire instrument, which was adjusted to the context of early university students in Malaysia. This instrument demonstrated strong internal consistency with a Cronbach's alpha value of 0.949, as well as high Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy values ranging from 0.89 to 0.97 for each variable.

The questionnaire, consisting of 23 items, was divided into three main components. The first component focused on collecting respondents' demographic data through five specific items. The second component concentrated on students' inclination to participate in online learning. The final component evaluated five dimensions of challenges in online learning, covering social aspects, lecturers, accessibility, academics, and generic skills. Responses for all items, except for the demographic section, were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Procedure and Participants

This study used Google Forms as the survey platform, which was distributed to students by the researcher using social media. As mentioned in the study by Saputri and Nurulwati (2022), Google Forms was chosen due to its relative ease of use and effectiveness because data collection can be done online which saves more time, energy and cost besides aiding environmental conservation policies such as paper-less.

Purposive sampling is used to identify respondents that should provide the most suitable and relevant information with the aim of increasing the depth of understanding (Campbell et al., 2020). Therefore, this study targets public higher education students in Malaysia specializing in mathematics who have experience with distance learning throughout their studies. The majority of students are in the age range of 20-30 years with undergraduate studies, followed by master's degrees, and a small number are pursuing doctoral degrees. This range of academic representation was deliberately sought to obtain a multi-dimensional picture of distance mathematics studying process in terms of learning challenges at various mathematical complexity and learning maturity levels since undergraduate and postgraduate learners might have specific valid challenges during online mathematics learning. Ethical aspects of the study were focused by asking participants to provide the consent through the click of the button 'next' when they were ready with the information provided within the study. Participation was voluntary and the study successfully collected 51 responses.

Data Analysis

The statistical package for the social sciences version 29 was used to perform the statistical analysis of the data. To determine the variables in the study, a principal component factor analysis (PCFA) with a varimax rotation was employed. The elements that were more likely to be viewed as obstacles that students would face in an online learning environment were determined using means. Cronbach's alpha was used to assess the scales' reliability. Every single item's mean, standard deviation, and Cronbach' alpha were also looked at. Additionally, a hierarchical multiple regression analysis was performed to ascertain whether the dependent variable–students' perspectives–can be predicted by social issues, lecturer issues, accessibility issues, academic issues and generic skills.

FINDINGS

The KMO value obtained in this study, which is a measure of sampling adequacy, was equal to 0.858, exceeding the required value of 0.6, as recommended by Kaiser (1970). Further, Kaiser (1974) has considered KMO values above 0.80 to be 'meritorious', hence the suitability of the selected sample for factorial analysis. Moreover, all items showed communalities exceeding 0.500, indicating a shared variance among the items. These findings confirm the suitability of using factor analysis on the 23 items studied.

An examination of the 23-item survey through PCFA revealed six key factors: students' perspective (74.986%), social issues (11.305%), lecturer issues (8.109%), accessibility (4.252%), academic issues (0.894%), and generic skills (0.453%). Cronbach's alpha analysis used to test the reliability of these scales with values exceeding 0.80 thus fulfilling the generally acceptable test of reliability for research on human beings (Green et al., 1977). **Table 1** shows factors, items, and descriptive statistics.

A comparative analysis of variable means was conducted (**Table 2**) to identify the primary challenges students encounter in distance learning of mathematics.

The data presented in **Table 2** highlights lecturer-related factors (mean = 2.8235) as a crucial challenge for students pursuing mathematics through distance learning. Although participants ranked lecturer issues as their foremost concern, the mean scores across other

Table 1. Factors, items, and descriptive statistics

Factor	Item	M	SD	CA
Student perspectives	I prefer online mathematics learning to be discontinued	3.06	1.348	0.903
	The online mathematics learning environment is not motivating	2.90	1.204	
	Online mathematics learning does not achieve student objectives.	3.04	1.232	
	I lack personal motivation for online mathematics learning.	2.80	1.281	
	I prefer the semester to be postponed	4.12	1.089	
Social issues	Online mathematics learning is unbalanced and makes students feel isolated.	2.73	1.250	0.904
	Lack of communication between students.	2.12	1.177	
	Lack of group discussions during assignments.	2.43	1.253	
	Online mathematics learning is too indirect	2.76	1.290	
Lecturer issues	Lower quality of online mathematics materials.	3.16	1.046	0.872
	Lack of clear expectations or learning outcomes in mathematics from lecturers.	2.57	1.063	
	Insufficient instructors to assist in delivering lessons.	2.84	1.084	
	Sharing of teaching materials may be delayed online.	2.71	1.082	
	Lecturers or instructors are not trained to teach online	2.84	1.027	
Accessibility	Required technology is not available.	2.94	1.240	0.811
	Some applications are not compatible with phones and laptops.	2.14	0.917	
	Issues with the correct browsers for learning mathematics.	2.24	1.012	
	Lack of stable internet access.	2.18	1.108	
	The cost of internet packages is too high.	2.45	1.222	
Academic issues	Lack of effective communication skills.	2.31	1.086	0.803
	Lack of skills in independently reading instructional materials.	2.45	1.119	
Generic skills	Online mathematics learning has caused me to lack good writing skills.	2.82	1.212	0.851
	Online mathematics learning has caused me to lack mastery of vocabulary	2.78	1.205	

Note. M: Mean; SD: Standard deviation; & CA: Cronbach's alpha

Table 2. The most important challenges students face in distance learning

	Mean	Standard deviation
Social issues	2.5098	1.09540
Lecturer issues	2.8235	0.86223
Accessibility	2.3882	0.83466
Academic issues	2.3824	1.00791
Generic skills	2.8039	1.12729

dimensions–social, accessibility, academic, and generic issues–exhibited similar values.

To examine which, challenge factors (social issues, lecturer issues, accessibility, academic issues and generic skills) contributed more to the students' perspective in studying mathematics in distance, a standard multiple regression analysis was conducted. Overall, the results showed that the predictive model was significant, $F(5, 45) = 17.209$, $R^2 = 0.657$, $p < 0.001$. Only one of the predictors, namely social issues explain a large amount of the variance between the variables (65.7%). Social issues is a significant positive predictors of students' perspective in mathematics distance learning ($\beta = 0.673$, $t = 4.073$, $p < 0.001$) while the other predictors showed non-significant relationships in predicting the students' perspective. Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial (or 'part') correlations (sr^2) for each predictor in the regression model are reported in **Table 3**.

DISCUSSION

This study explores the perspectives and challenges in distance learning of mathematics among mathematics students in public higher education institutions in Malaysia. The findings indicate that the biggest challenge faced by students is issues related to lecturers. These findings are consistent with previous studies, which show that the quality of lecturers' teaching is a critical factor in distance learning, particularly online (Nhuong et al., 2022). These include the poor quality of teaching materials, especially in mathematics, which we can attribute to students' concern about the quality of lectures that they are subjected to. The challenge becomes more pronounced in distance learning environments where traditional face-to-face instructional strategies, such as strategic oral questioning that has been shown to improve students' mathematical language fluency and conceptual understanding (Mahmud et al., 2020), are difficult to implement effectively in online formats. Conversely, students showed appreciation when the selected platform used for online classes was appropriate and when teachers provided well-developed explanations and quality digital content (Borges & Costa, 2022). Furthermore, students struggle in those situations when a lecturer or an instructor lacks experience in teaching mathematics online as well as when there are not enough instructors to teach. This is in support of the study conducted by Zin and Mahmud (2024), arguing that due

Table 3. Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial (or 'part') correlations (sr^2) for each predictor in the regression model

Variable	B [95% confidence interval]	β	sr^2	t	Significance
Social issues	0.643	0.673	0.356	4.073	< 0.001
Lecturer issues	0.312	0.257	0.130	1.484	0.145
Accessibility	-0.405	-0.323	-0.222	-2.545	0.014
Academic issues	0.181	0.174	0.120	1.376	0.176
Generic skills	-0.023	-0.025	-0.018	-0.202	0.841

to poor technical and online teaching competencies, the quality of interaction with students is likely to be compromised and so is the ability to successfully convey complicated concepts in mathematics. Compounding this situation are aspects like the delays in sharing teaching notes online and the failure of lecturers to provide clear instructions or goals that the students need to meet in mathematical learning: as pointed out by the students in this study. The reliability of this data is supported by a high Cronbach's alpha value of 0.872, indicating good internal consistency for the constructs related to lecturer issues. These findings highlight the urgent need to enhance lecturers' competencies in teaching mathematics remotely and efforts to strengthen the quality of digital mathematics teaching materials.

Therefore, this study reminds lecturers to prepare distance learning with more careful and systematic planning. As suggested by Zahran (2008), engagement and social presence should also be integrated into distance learning planning. Furthermore, Gandhi et al. (2023) emphasize that institutions must play a role in supervising lecturers' planning. This supervision is crucial to prevent the poor quality of the required digital mathematics teaching materials and to facilitate sufficient support for the lecturers in the process of distant mathematics classes. This also includes ensuring that lecturers have adequate training in digital pedagogy, providing clear guidelines for online teaching, and monitoring the effectiveness of distance learning implementation. The analysis by Mavroudi and Papanikolaou (2022) supports this argument as they have demonstrated that online course design requires significant time and well planning.

This study also found that students strongly agreed to the postponement of the semester, with the highest mean score. This reflects the level of concern students have regarding the effectiveness of distance learning in mathematics. These findings are similar to those of Cahyati et al. (2022) where students reported perceived behavior and academic performance concerns related to the ability to attain the expected learning outcomes through distance learning. This concern is reflected in student feedback, which indicated that online mathematics learning did not meet the learning objectives (mean = 3.04) and the online mathematics learning environment was not motivating (mean = 2.90).

As stated by Lailiyah et al. (2021) online mathematics learning is the one that needs a different approach, and due to unexpected transition to online, such pressure may be felt by students. In addition, mathematics students need more face-to-face contact and support when it comes to mastering the material, which is not quite attainable in an online educational format (Loch et al., 2016). Teachers prefer traditional in-person classroom instruction (Jarrah et al., 2024). Cassibba et al. (2020) study also identified challenges that most university mathematics students undergo while learning under distance learning since most mathematics concepts can only be understood through face-to-face interaction with the lecturers. The case in point is limits, continuity, and structures of groups in group theory; these mathematical constructs are abstract in the sense that heavy explanation is necessary and metaphor-driven gestures are required so that students have a visualization of constructs they are unable to touch (Cassibba et al., 2020). Moreover, mathematical language, in the strict meaning which implies complicated symbols and formulas, would be much harder to follow when not taught in step-by-step processes on the blackboard. This research reaches a finding that the preferred solution among the students is the postponement of semesters with a mean score of 4.12 among the students suggesting that there is a necessity to review the approach by institution to make distance mathematics learning effective and contributing to the achievement of learning objectives.

Further analysis of standard multiple regression reveals that social issues are the most significant factor influencing students' perspectives on mathematics distance learning. This finding highlights the critical role of interpersonal interaction in shaping positive learning experiences. Social interaction and social presence have been identified as important precursors for meaningful learning to occur and have been demonstrated to positively impact perceived learning (Mehall, 2020). Despite the fact that mathematics is often perceived as an individualistic subject due to the involvement of individual cognitive, emotional, motivational and self-concept related variables that interact within and across domains (Szűcs & Mammarella, 2023), our result emphasizes the influence of social engagement in an online learning environment, particularly in mathematics.

However, in distance learning space, students frequently had a hard time obtaining meaningful learning due to the absence of physical presence. These

challenges align with the CoI framework which emphasizes the importance of social presence for creating engaging and supportive online learning environments. In this framework, social presence is the ability of students to project themselves socially and emotionally while making them feel real to each other in an online environment (Swan, 2019) but the opposite is happening in this study. The social isolation due to lack of peer communication, restricted collaboration and indirect learning could often lead to disengagement. These issues are essentially pronounced in mathematics where complex problem-solving is hand-to-hand with immediate feedback from classmates and instructors. Providing immediate feedback after an error is made could prevent the carry-over of errors as mentioned by Corbalan et al. (2010). For instance, in face-to-face calculus classes, when a student incorrectly applies the chain rule during differentiation, the instructor can immediately intervene and demonstrate the correct approach on the blackboard. Conversely, distance learning structures tend to give a lag between the instances of errors and correction.

Several social challenges were highlighted by students in our study including social isolation. This finding matched with study from Akese et al. (2024) who mentioned that the most important psychological effect of distance learning for many students is social isolation that is resulting from the lack of face-to-face interaction among peers and instructors. Before distance learning, students were so used to being in a physical environment where they could meet and interact with their classmates directly. However, in many cases, the sense of community and involvement is relatively low in online classes as studied by Bao (2020).

This is also due to the fact that there are missing opportunities for collaborative problem solving and shared learning experiences. The collaboration is restricted as the respondents agreed that there is a lack of discussion in group tasks. Donelan and Kear (2023) found that lack of clarity is the main reason for low participation in online group discussions. Students are unclear with the instructional guidelines (An et al., 2008) and have unclear objectives (Ekblaw, 2016). Other than that, scheduling or time issues are also well-documented in online group work, especially in distance learning where students are often in paid employment or need to juggle with other commitments (Donelan & Kear, 2023).

Next, to dampen the impact of social issues in mathematics distance learning, there are few proposed recommendations such as encouraging peer collaboration by utilizing breakout room discussions and incorporating peer review activities into the syllabus to sharpen teamwork and collective problem-solving skills, enhancing instructor interaction and creating structured opportunities for social interaction.

CONCLUSION

This study has provided a comprehensive overview of the perspectives and challenges in distance learning of mathematics among mathematics students in public higher education. Through the analysis conducted, the study successfully identified lecturer-related issues as the main challenge, with social issues emerging as a significant positive predictor of students' perspectives on distance learning in mathematics. The study also found that students showed a very high level of agreement with the proposal to defer the semester, reflecting serious concerns about the effectiveness of distance learning in mathematics.

The findings of this study can be integrated with the CoI theory, which emphasizes three key elements: social, teaching, and cognitive presence. The significant influence of social issues on students' perspectives reflects that this aspect greatly affects the effectiveness of forming an effective online learning community. The implementation of e-learning and distance education technologies allows putting completely new forms and methods of teaching into practice, potentially enhancing all three elements of the CoI framework when properly utilized (Zykova et al. 2018). From a pedagogical standpoint, lecturers are required to employ other comprehensive teaching and learning strategies that promote all three CoI elements. This can be done by designing learning activities that foster students' collaboration in the course [social presences], offering supportive guidance and feedback [teaching presence], and employing the approaches that support construction of meaningful schemas about mathematics [cognitive presence]. This should be accompanied by good communication to allow the students to read and comprehend the learning objectives and be able to meet them.

Based on the findings of this study, several important implications need to be considered for the improvement of distance learning in mathematics. First, from the institutional viewpoint, the emphasis should be laid on creating the extensive training which will improve the competencies of the lecturers concerning the use of technologies in mathematics distance instruction. Such programs should include areas like designing of learning-teaching activities, teaching approaches in teaching mathematical content, systematic routine-checking. From the aspect of students' support, institutions are required to offer the following aspects: mentoring, embracing skills in self-learning, time management, and mastery of technological skills. More attention should therefore also be paid to online collaborative learning activities to take as key factors highlighted in this study as important in causing social isolation. Last of all, it is advised to establish clear directions on how distance learning in mathematics should be applied, while including the elements of the

CoI. This includes standards for social interaction, teaching quality, and effective mathematical knowledge construction strategies in the distance learning environment.

There are several limitations that need to be considered in interpreting the findings of this study. This research only focuses the mathematics students on public higher learning institutions in Malaysia and this may not be generalized for the private colleges or at other levels of education. Since quantitative methods using questionnaires as the main data collection tool may not provide depth of experience and difficulties encountered by students in a distance learning environment in mathematics. The study also did not account for disparities in digital learning facilities, and education administration between urban and rural areas, as well as socioeconomic factors that may impact the effectiveness of distance learning. Furthermore, the learning preferences of learners and their willingness to perform self-regulated learning were not analyzed. The above stated limitations should be taken into consideration when designing subsequent research on distance learning in mathematics with an aim to achieve a better understanding of the distance learning.

In conclusion, the success of distance learning in mathematics requires a holistic approach involving the collaboration of all stakeholders. The findings of this study provide a solid foundation for continuous improvement in the implementation of distance learning in mathematics at higher education institutions in Malaysia.

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